REMARKS

Claims 1-26 are pending in the present application. In the Office Action mailed June 10, 2005, the Examiner rejected claims 1-26 under 35 U.S.C. §102(b) as being anticipated by Liu et al. (USP 5,621,321). The Examiner next rejected claims 11-14 and 16-18 under 35 U.S.C. §102(b) as being anticipated by Sandford et al. (USP 5,451,876). Claims 1, 9, 10, and 15 were rejected under 35 U.S.C. §103(a) as being unpatentable over Sandford et al. in view of Liu et al.

Claims 1-10 have been amended to clarify that the correction of MR data for amplitude modulation effects in the FSE pulse sequence occurs prior to 2D Fourier transforming of the corrected MR data. In this regard, one skilled in the art would readily appreciate that the claimed correction is carried out on data that is in k-space rather than image space. As such, claims 1-10 have also been amended to replace "MR data" with "k-space data". As will be explained more fully below, the art of record fails to teach or suggest correction of k-space data for amplitude modulation effects in a FSE pulse sequence.

In the art of MR imaging, k-space is well-known as the repository for spatial frequency signals acquired during evolution and decay of an excited echo. K-space is a matrix generally defined by a k_x axis (along the rows) and a k_y axis (along the columns), and each have units of cycles/unit distance. Each axis is symmetric about the center of k-space, ranging from $-f_{max}$ to $+f_{max}$ along the rows and the columns. Generally, low frequency signals are mapped around the origin of k-space and high frequency signals are mapped further from the origin in the periphery. Conventionally, the k-space matrix is filled one row at a time with the frequency encoding gradient induced frequency variations mapped along the k_x axis and the phase encoding gradient induced phase variations mapped along the k_y axis. Following data acquisition, a 2D Fourier transform is applied to the k-space matrix. The 2D Fourier transform yields the corresponding frequency values (positions) and amplitudes as a single output value in the spatial domain. Grayscale values are determined according to the amplitude of the signal at each spatial frequency. That is, the 2D Fourier transform encodes the variations along the k_x

and k_y axes into the corresponding locations along the x and y axes in image space. An image is then reconstructed from the data represented in the image space.

The 2D Fourier transform is carried out as a series of 1D Fourier transforms. In this regard, the grayscale image is formed by the sequential application of a 1D Fourier transform along each row with intermediate results stored in a buffer. A subsequent 1D Fourier transform is then applied along each column of the intermediate buffer. The output matrix (image space) resulting from the two 1D Fourier transforms is used to generate a final image that captures spatial and contrast characteristics according to T_1, T_2, proton density, and/or flow characteristics of an object using a grayscale range.

Referring now to that disclosed by Liu et al. The Examiner relied upon Liu et al. to assert that claims 1-26 are anticipated. However, the reference teaches an amplitude correction technique whereby corrective measures are taken after the k-space data undergoes a row-by-row Fourier transform. See col. 12, ll. 40-54. That is, "imaging data is subject[ed] to the one-dimensional Fourier transform 72." Id. Liu et al. defines the "one-dimensional Fourier transform 72" as a row-by-row transform that is applied in the read out direction. Id., at ll. 46-47.

Further, Liu et al. teaches that for the "intensity correction…each once Fourier transformed calibration complex data line … is used to generate an intensity correction factor…" Col. 12, ll. 54-58. Liu et al. further teaches, "In the intensity correction step 90, each previously phase corrected data line is intensity corrected…" Col. 13, ll. 16-18. However, Liu et al. further teaches that "it will be appreciated that the phase and intensity corrections can be performed in a single step." Col. 13, ll. 23-24. In any event, "the final complex image $im_{s,En}(x,y)$ is obtained with a column one-dimensional Fourier transform 100 along the phase encoding direction…" Col. 13, ll. 24-33. Thus, it is clear from the direct teachings of Liu et al. that any amplitude correction is carried out on MR data that minimally has undergone a row-by-row Fourier transform. In other words, Liu et al. teaches correcting for amplitude intensity variations in MR data after the first 1D Fourier transform of a conventional 2D Fourier transform has been carried out.

In contrast, claim 1 has been amended to clarify that the step for correcting for amplitude modulation effects in the FSE pulse sequence is carried out on acquired k-

space data and prior to 2D Fourier transforming of the k-space to generate an image space. As described above, 2D Fourier transforming includes a pair of 1D Fourier transforms: a row-by-row transformation and a column-by-column transformation. Therefore, with the amendment to claim 1, it is clear that the claimed amplitude modulation correction takes place before the row-by-row Fourier transform of a 2D Fourier transform. Liu et al., at best, teaches an amplitude modulation correction technique that is applied after the conventional 2D Fourier transform has begun. As such, it is believed that claims 1-10 are in condition for allowance.

The Examiner also rejected claim 11 as being anticipated by Liu et al. Claim 11 has been amended to clarify that the modification of the acquired MR occurs while the acquired MR data is entirely in k-space. At best, as stated above, Liu et al. teaches a method of amplitude intensity variation correction that is applied after a row-by-row transformation. In this regard, the acquired MR data is no longer entirely in k-space when the correction efforts are made. The acquired MR data is in a matrix that has one axis defined in the time domain and the other axis in the frequency domain. This "intermediate" matrix is considered a buffer matrix and it is this matrix of data that Liu et al. teaches the application of its phase and intensity variations corrections. The "intermediate" matrix is not k-space as the data points therein no longer represent spatially dependent frequency variations as a function of spatially dependent phase shift variations. Accordingly, it is believed that claims 11-18 call for subject matter patentably distinct from the art of record. Allowance thereof is requested.

Claims 19-26 also stand rejected as being anticipated by Liu et al. Claim 19 has been amended to incorporate the subject matter previously presented in claim 23. Claim 23 has been canceled.

In the rejection of claim 23, the Examiner asserted that Liu et al. teaches the modification of each data point of k-space with a similarly positioned amplitude correction value found in a set of amplitude correction values arranged in a table dimensionally equivalent to the k-space. The Examiner's conclusion, however, ignores the explicit teachings of the reference.

Liu et al. teaches an intensity correction whereby "each previously phase corrected data line is intensity corrected..." Col. 13, ll. 16-18. In this regard, "a magnitude correction circuit 92 determines an appropriate amplitude correction for each echo in the series and the intensity correction circuit 90 adjusts the amplitude of each data line correspondingly." Col. 6, ll. 20-24. As the technique of Liu et al. is directed to accounting for amplitude variations between echoes and given that each echo represents one data line, it is clear that intensity correction is carried out on a line-by-line basis, not a point-by-point basis. See col. 5, ll. 43-44.

In contrast, claim 19, as amended, calls for a point-by-point modification of k-space with a corresponding amplitude correction value. In this regard, the computer is caused to generate a set of amplitude correction values from non-phase encoded MR data and arrange the set of amplitude correction values in a table dimensionally equivalent to a k-space of phase encoded MR data. As such, each k-space point of phase encoded MR data has a counterpart correction value derived from non-phase encoded MR data. Accordingly, each data point of k-space is individually and independently corrected. Liu et al., on the other hand, treats the data from a single echo equally, i.e. all the data points in a given data line are modified by the same correction factor. Therefore, in light of the amendment of claim 19, it is believed that claims 19-22 and 24-26 are in condition for allowance.

Claims 11-14 and 16-18 stand rejected as being anticipated by Sandford et al. Claim 11 has been amended to incorporate the subject matter of claim 15. Claim 15 has been canceled. As the Examiner has previously indicated that Sandford et al. does not teach that called for in claim 15, Applicant believes the rejection of claim 11 based on Sandford et al. to be moot.

Claims 1, 9, 10, and 15 stand rejected as being unpatentable over the combination of Sandford et al. and Liu et al. As stated above, claim 11 has been amended to incorporate the subject matter of claim 15 and claim 15 has been canceled. With respect to the teachings of Liu et al., Applicant refers the Examiner to the remarks made hereinabove. Sandford et al. is directed to an MRI system with dynamic receiver gain whereby the gain of a receiver is dynamically changed during a scan to provide an

optimal SNR figure without over-ranging the transceiver's A/D converter. In this regard, Sandford et al. teaches a system that picks up an NMR signal produced by a subject with a receiver coil and the NMR signal is amplified by an amount determined by a digital attenuation signal received from a backplane. Col. 4, ll. 37-43. Sandford et al. teaches a signal modification technique that "chang[es] the digital attenuation signal applied to the receiver during the scan so that NMR signals of widely varying amplitude can be acquired at an improved SNR." Col. 5, ll. 3-7. See col. 5, ll. 40-41. In this regard, the reference teaches the normalization of acquired NMR signals so that the amplitude of an acquired signal is adjusted to account for its receive attenuation used during acquisition. See col. 5, ll. 5-10. In other words, Sandford et al. discloses an imaging technique that amplifies an NMR signal for improved SNR and normalizes the amplified NMR signal to account for the amplification. One skilled in the art would readily appreciate such a technique does not correct acquired MR data for amplitude modulation effects present in a fast spin echo sequence used to acquire the MR data. As such, neither Liu et al. nor Sandford et al. teaches or suggests that called for in claims 1 and 9-11. Allowance thereof is requested.

Therefore, in light of at least the foregoing, Applicant respectfully believes that the present application is in condition for allowance. As a result, Applicant respectfully requests timely issuance of a Notice of Allowance for claims 1-14, 16-23, and 24-26.

Applicant appreciates the Examiner's consideration of these Amendments and Remarks and cordially invites the Examiner to call the undersigned, should the Examiner consider any matters unresolved.

Respectfully submitted,

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Dated: June 27, 2005
Attorney Docket No.: GEMS8081.191

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